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Raytheon

AIR-/GROUND-BASED IR BACKGROUND MEASUREMENTS PROGRAM

ADDENDUM TO FINAL REPORT

BR-19101-ADDENDUM
AUGUST 1990

Contract No.: N[illegible]4-85-C-2823

MISSILE SYSTEMS LABORATORIES
Tewksbury, Massachusetts

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BR-19101-ADDENDUM
AUGUST 1990

Prepared for
NAVAL REASEARCH LABORATORY
Washington, D.C.

Contract No.: N00014-85-C-2623
Data Item: A004

Prepared by
RAYTHEON COMPANY
MISSILE SYSTEMS LABORATORIES
Tewksbury, Massachusetts

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1. INTRODUCTION

The Naval Research Laboratory's (NRL's) contract with Raytheon Company for the Air/Ground-Based IR Background Measurements Program consisted of two basic tasks:

1) **Task 1** - The collection of IR radiometric background data from airborne and ground platforms using Raytheon's Two Color (3-5μm and 8-12μm) Radiometer. Raytheon's activities consisted of field measurements at sites selected by NRL.
2) **Task 2** - Supporting services, as requested by NRL, related to acquiring IR background data.
   During the basic contract these services were largely centered on bringing the Infrared Analysis, Measurement and Modeling Program's (IRAMMP) radiometric dual band sensor into use. The IRAMMP sensor was designed and built by Raytheon for the Naval Surface Warfare Center under contract N60921-84-C-0060. Raytheon's activities included support of the sensor's integration with other Government equipment, notably a P-3 aircraft, and its inaugural data taking events both from the ground and from the P-3 aircraft.

Task 2 also allowed for "other tasks (that) may arise as sponsor interest increases." In that connection Raytheon was instructed, by a modification to the contract, to design, build, and deliver a Forward Looking Mirror (FLM) for use as an accessory to the Raytheon-built IRAMMP sensor. In flight the IRAMMP sensor customarily views the scenery out the side of its host aircraft. The Forward Looking Mirror is a single reflecting surface with mechanical adjustments in its mounting that allow the sensor's line of sight to be rotated forward (or at other suitable angles) for radiometric background measurements.

Tasks 1 and 2 above constituted the bulk of the principal contractual efforts and led to the following deliverables; namely,

1) Data tapes obtained during measurements under Task 1 (Data Item A002)
2) The Forward Looking Mirror hardware
3) Bimonthly Progress/Financial Reports (Data Item A001)

After the submission of the Final Report, a contract extension (Modification P00018 to Contract N00014-85-C-2623) was negotiated between NRL and Raytheon to allow an additional work element under Task 2 sponsored by the Naval Air Development Center (NADC), Warminster, PA.

The NADC Addendum SOW contained the following task description; namely,

> Conduct a conceptual design study to adapt the Government-owned Dual Band Radiometric Sensor System (known as the IRAMMP sensor) for infrared radiation polarization measurements. Raytheon has all the relevant plans required to conduct the design study. Therefore, the Government sensor will not be delivered to the contract to complete the 90-day study.

Further, the contract Data Requirements List (DD Form 1423) was expanded to include Sequence A004, an Addendum to the Final Report (Sequence A003) with delivery of the Addendum required 60-days after completion of the study. The Addendum contains the results of the additional conceptual design study.

At the beginning of work under the contract Addendum, Raytheon and NADC personnel met at NADC in Warminster, PA, to discuss detailed work to be performed. At this meeting, it was learned that NADC's desired for IRAAMP modifications really contained three IRAAMP hardware modification designs rather than one as originally perceived by Raytheon. These three modification designs were:

Option 1: (The originally perceived modification). Conduct a conceptual design study to adapt the IRAAMP sensor for infrared radiation measurements in the LWIR band in two cross-polarized channels, simultaneously.

Option 2: Conduct a conceptual design study to adapt the IRAAMP sensor for infrared radiation measurements in the LWIR band in two subband spectral channels, simultaneously.

Option 3: Conduct a conceptual design study to adapt the IRAAMP sensor for infrared radiation measurements in the MWIR band in two cross-polarized channels, simultaneously.

It was further desired that each modification be implementable in a reversible fashion without prejudicing the operability of the original IRAAMP configuration when restored.

Raytheon, in reviewing these various options, decided that they were somewhat similar from a conceptual standpoint. Therefore, Raytheon decided to address the group of modifications in such detail as allowed by the contractual statement-of-work and the available funding. However, the original equipment was not designed with easily replaceable retro-fits in mind; thus, it has proven necessary to modify somewhat the original equipment design with the required changes in mind. That is, it is first necessary to create a "standard" permanent modification with output functions identical to the original IRAAMP sensor delivered under Contract N60921-84-C-0060, but differently implemented, primarily in the manner of detector circuit board wiring. This "standard" permanent modification (or device) would then be able to be temporarily modified in the reversible manner desired and discussed above.

This approach, whose summary characteristics are contained in Table 1-1, is recommended by Raytheon and is shown to be practical and effective in the following design modification discussion.

TABLE 1-1 - SUGGESTED MODIFICATIONS TO BASIC IRAAMP SENSOR

Modification Identify	Detector Channel Characteristics		Optical Beam Splitter Type	Comments
	Channel 1	Channel 2		
Option 0	120 element staggered linear array of PV-InSb elements for MWIR band	120 element staggered linear array of PC-MCT elements for LWIR band	MWIR/LWIR Dichroic	Standard permanent modification with outputs identical to original design
Option 1	120 element staggered linear array of PC-MCT elements for LWIR band	120 element staggered linear array of PC-MCT elements for LWIR band	LWIR/LWIR "Wire-Grid" polarizer	Temporary modification
Option 2	120 element staggered linear array of PC-MCT elements for LWIR subband 1	120 element staggered linear array of PC-MCT elements for LWIR subband 2	LWIR/LWIR dichroic or 50-50 type	Temporary modification
Option 3	120 element staggered linear array of PV-InSb elements for MWIR band	120 element staggered linear array of PV InSb elements for MWIR band	MWIR/MWIR "wire-grid" polarizer	Temporary modification

2. CURRENT IRAAMP DESIGN

The current IRAAMP Sensor is described in the IRAAMP Final Report, BR-17965,[1] and in the Maintenance and Operating Instructions, BR-17966[1]. Here we shall discuss the sensor's current characteristics only to the extent necessary to justify the recommended changes.

2.1 Current Design Configuration

The basic IRAAMP opto-mechanical package is shown in Figures 2-1, 2-2 and 2-3 with the opto-mechanical schematic shown in Figure 2-4. the dual band sensor measures IR scene characteristics in both the 3-5μm and 8-12μm bands simultaneously. Two separate staggered 120-element linear arrays operate in the two wavelength bands; photovoltaic indium antimonide (InSb) in the 3-5μm band and photoconductive mercury cadmium telluride (HgCdTe) in the 8-12μm band. The arrays detector are located in common module dewars (type DT594), modified with a long (geometric) cold shield for each detector array, which suppresses the arrival of photons from places other than the IR scene being viewed.

The sensor optics has a 4 in. aperture and uses off-axis reflective optics to avoid obscurations and the wavelength dispersion corrections which would be required by refractive optics. The optical paths, illustrated in Figure 2-4, is a three mirror, all reflective, off-axis, anastigmatic design with external scan mirror. It has a dichroic spectral filter, or beam splitter, to separate the incoming radiation into the 3-5μm and the 8-12μm wavelength bands to be focused on the respective detector. All optical elements are at ambient temperature. Coldshielding is accomplished by placing the dewar's coldshield at the final exit pupil. In this manner, greater than 95 percent geometric coldshield effectivity is obtained.

The sensor has a set of five subband spectral filters in the MWIR band. These are mounted in an eight position filter wheel in front of the MWIR detector/dewar. The desired filter is selected from the control panel. The LWIR band has a single filter located in a two position mount that can be actuated by a lever on the sensor. In the LWIR band the system is focused with the filter in the optical path. If the filter is switched out, the system must be focused to operate properly.

A hot and cold internal reference was constructed by using two sets of mirrors and a blackbody source. The cold reference is provided by two narcissus mirrors (one in front of each detector) to reimage the cold FPA temperature on the detector. At the start of each right or left scan, the three mirrors are actuated. Both the cold narcissus mirror and the hot reference mirror swing into position in front of each detector/dewar. The cold mirror is between the dewar window and the hot mirror. The cold mirror reimages the detector onto itself thus creating the cold reference. The cold mirror then swings back to its normal position and the hot mirror images the internal blackbody source onto the detector. The hot mirror then swings out, back to its normal rest position, and after a delay the field-of-view is scanned. The mirrors may be disabled by two switches on the front control panel. The blackbody source temperature is controlled by a ten turn potentiometer on the control panel. The temperature of the blackbody is read on a digital panel meter.

Field-of-view scanning by the detector arrays is accomplished by a driven plane mirror located in front of the focussing optics. This location avoids the scan modulation effects often associated with internal scanning schemes. The total field-of-view can be selected to be 5.625 deg x 1.573 deg (azimuth x elevation), or 22.5 deg x 1.573 deg. Selectable scan rates are nominally 18 deg-sec and 36 deg-sec. The vertical field of view can be doubled, on an alternating traverse basis, by tilting the scan mirror. After the radiation is gathered and focused by the optical system, the two bands are separated by a fixed dichroic element and directed to their respective detector arrays. Elements in

[1] Raytheon Company Contract Reports

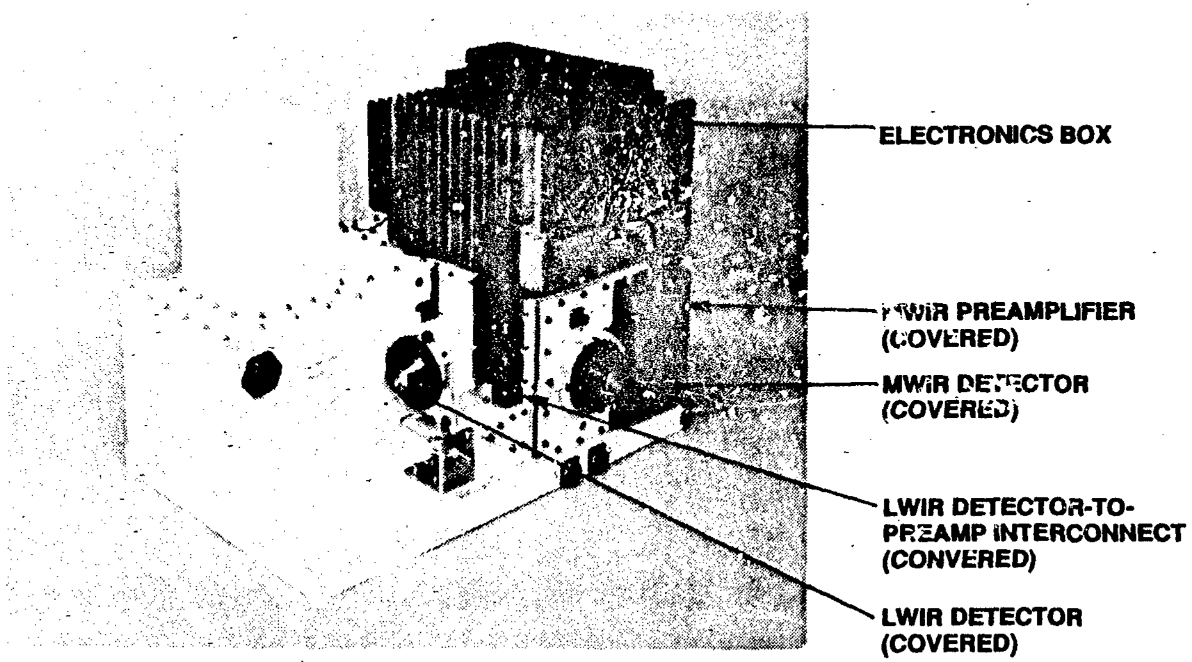

Figure 2-1 - IRAAMP Opto-Mechanical Structure - Fully Assembled

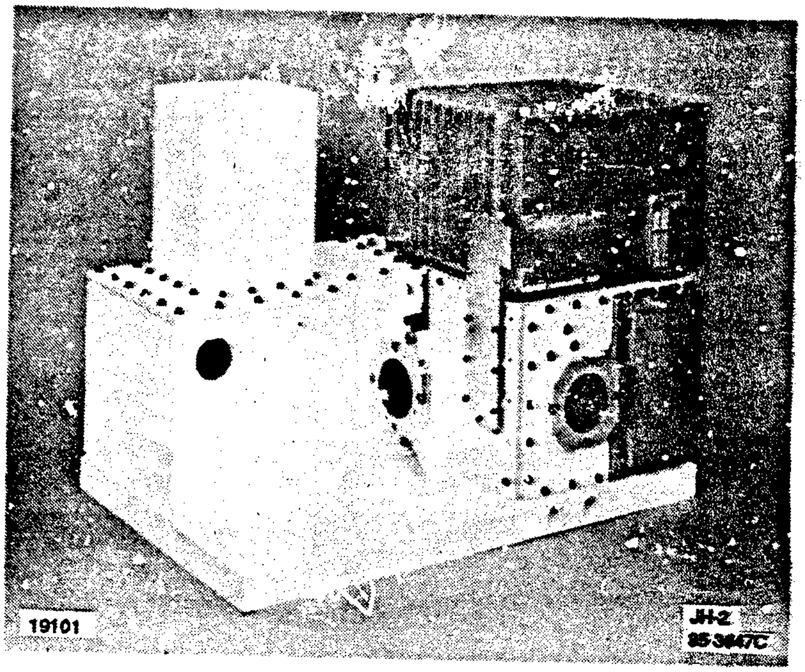

Figure 2-2 - IRAAMP Opto-Mechanical Structure (Detector Units Removed)

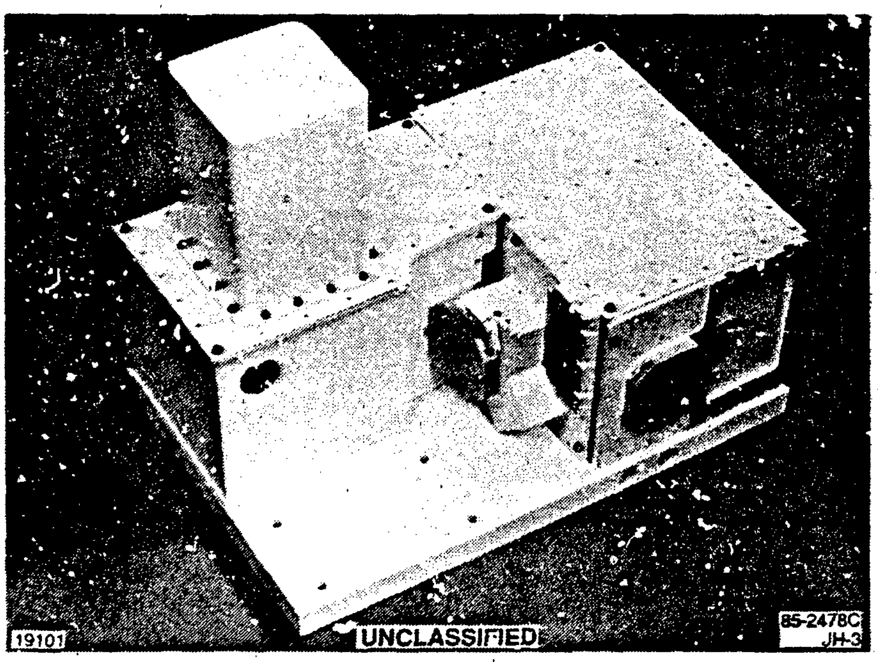

Figure 2-3 - IRAAMP Opto-Mechanical Structure (Detector Units and Associated Electronics Removed)

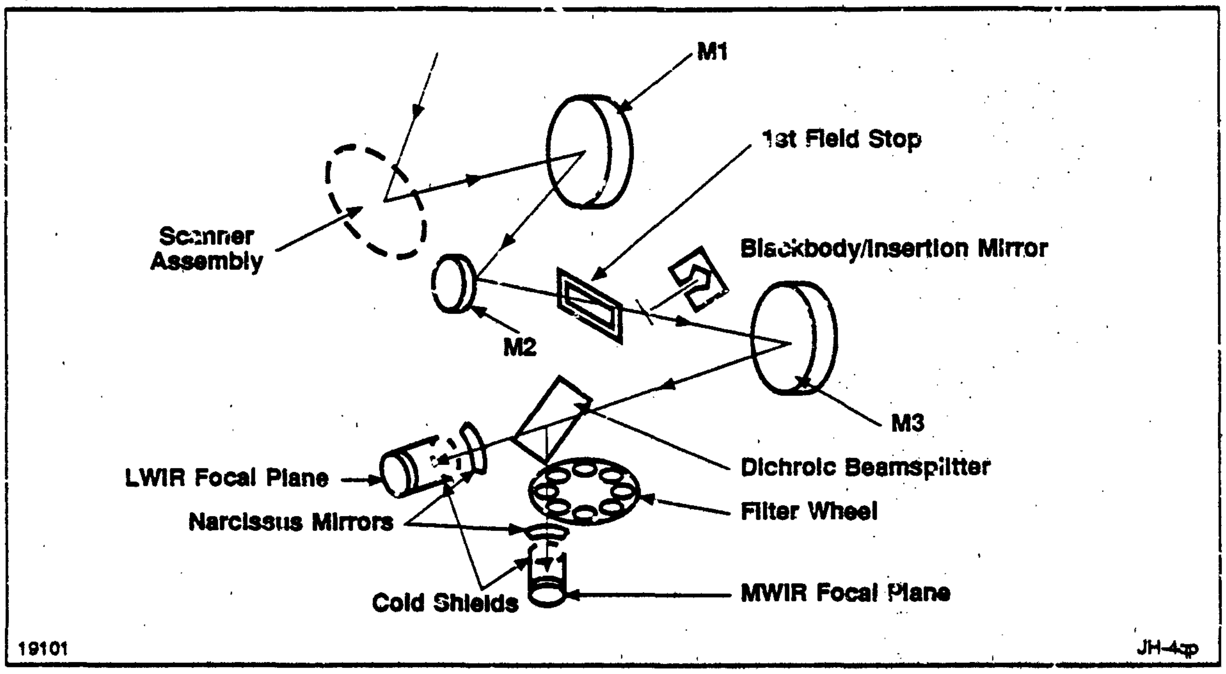

Figure 2-4 - IRAAMP Opto-Mechanical Schematic

these arrays are staggered so that they cover contiguous paths as they are scanned across the viewed scene.

The detector analog signals are fed through preamplifiers, post amplifiers and buffers (see Figure 2-5) to a Control Panel and a Data Acquisition System (DAS), (see Figures 2-6 and 2-7, respectively). The control panel also displays the temperature of the detectors and the blackbody source, as well as controls for selecting the desired MWIR subband spectral filter. The DAS, developed by the Naval Research Laboratory and Telemetrics, Corp., multiplexes and digitizes the analog signals from the detector postamplifiers for off-line processing. The final product is apparent radiance maps of the clutter fields where radiometric values and pixel to pixel contrasts are preserved. These radiance maps can be analyzed and characterized but, equally important, they can be utilized as inputs to candidate IRST Signal processors. The quality of the radiance maps is such that using them as inputs is nearly equivalent to looking at the actual scene with an operational IRST. A summary of the Technical characteristics of the Dual Band Sensor is given in Table 2-1.

TABLE 2-1 - SUMMARY OF TECHNICAL CHARACTERISTICS

Requirement	1984 Spec	1988 Spec	Actual Result	Units
Dual Window IR Operation				
Dual Window IR Operation	3-5αm 8-12αm	No change	Yes	
IFOV (AZ x EL)	0.25 x 0.25	0.22 x 0.23	Yes	mrad
TFOV (AZ x EL) 36 deg/sec scan speed	6 x 1.7	5.625 x 1.7 22.5 x 3.4	5.6 x 1.6 22.4 x 3.2	deg

TABLE 2-1 - SUMMARY OF TECHNICAL CHARACTERISTICS (Continued)

Requirement	1984 Spec	1988 Spec	Actual Result	Units
Acquire video during both directions	Yes	No change	Yes	
Scan Rate	72 36	36 18	33.4 17.6	deg/sec
Sensor to be compatible with stabilization jitter requirements	≤60 rms	≤125 rms	Yes	μrad
Sensor weight less than	60	80	Yes	lb
FPA (TDI) Compatibility	Yes	Yes	Yes	
Detectors No. Detectors/Waveband	120	No change	Yes	
1/f Noise Shoulder MWIR LWIR	0.5 800	No change	0.3 230	Hz
NEDT (pixel-to-pixel) at 36 deg/sec scan speed	0.15 Both bands	No change	MWIR 0.047 LWIR 0.032	°C
NEI (W/cm^2) MWIR LWIR 36 deg/sec scan speed	2×10^{-14} 2×10^{-13}	2.7×10^{-14} 2.7×10^{-13}	2.6×10^{-14} 1.6×10^{-13}	W/cm^2
Detector and electronics dynamic range	90	84	Yes	dB
Readout of detector temperature	Yes	No change	Yes	
Pixel Registration Single Color MWIR 0.25 LWIR 0.50		0.5 0.5	0.25 0.25	x IFOV x IFOV
Color-to-Color	Systematic; constant offset known to within 0.25 x IFOV	0.5	0.25	x IFOV
Detector Array Geometry (suggested)	Linear Staggered Array	No change	Yes	
Selectable spectral filters in 3-5 μm band	Switchable	No change	Yes	
Azimuth Shaft Encoder	18 Bit 50 μrad Resolution	No change	Yes	

TABLE 2-1 - SUMMARY OF TECHNICAL CHARACTERISTICS (Continued)

Requirement	1984 Spec	1988 Spec	Actual Result	Units
EMI Protection	Yes	No change	Yes	
Radiometric Accuracy				
Radiometric Accuracy Absolute Repeatability	 10% 3%	 No change	 Yes	
Electronics				
Preamps and Postamps Dynamic Range Video Passband (flat response) MWIR LWIR	90 dc-7500 0.2-7500	84 dc-2500 0.4-2500	Yes Yes Yes	dB Hz Hz
Crosstalk between channels less than	5%	No change	Yes	
Modular Telescope Design				
Telescope Aperture	 4-5	 4	 Yes	 in.
Cold shielding from photon flux from outside f/cone	>95%	No change	Yes	
Scan linearity less than	0.25	0.5	Yes	x IFOV

2.2 Current Electronics Design Configuration

The overall signals circuit block diagram was shown in Figure 2-5, where the MWIR and LWIR channels appear symmetric. However, due to the fact that the MWIR detectors are photovoltaic and the LWIR detectors are photoconductive, the physical configuration of the MWIR and LWIR signal channels are differently configured as indicated in Figure 2-8. Indeed the LWIR detector amplifiers are in the electronics box (see Figure 2-1; whereas, the MWIR detector preamplifiers are in a separate enclosure (see also Figure 2-1). These facts have a prefound effect on the design modification approach which leads to the recommended modification options.

2.2.1 LWIR Pre- and Postamplifiers

The pre- and postamplifiers circuits for the 120 LWIR detector are located on 12 circuit cards in the electronics box. There are 10 channels on each card. Included on each circuit card is a +12 V regulator and a -12 V regulator, which converts the ±15 V at the electronics box backplane, to provide power for the circuits on each card. Also, included on one of the LWIR amplifier cards is a temperature sensor circuit to sense the temperature of the LWIR detector, using a temperature sensing diode on the cold finger. This circuit sends a voltage proportional to the temperature to the front panel and to the DAS.

The output of each LWIR detector is connected to a preamplifier by means of a length of cable. This first stage of amplification is of extreme low noise design as not to degrade the system sensitivity. This stage offers substantial dynamic range thus eliminating the need for gain control. The preamplifier section consists of two transistors in a self-biasing design. The design provides low dy-

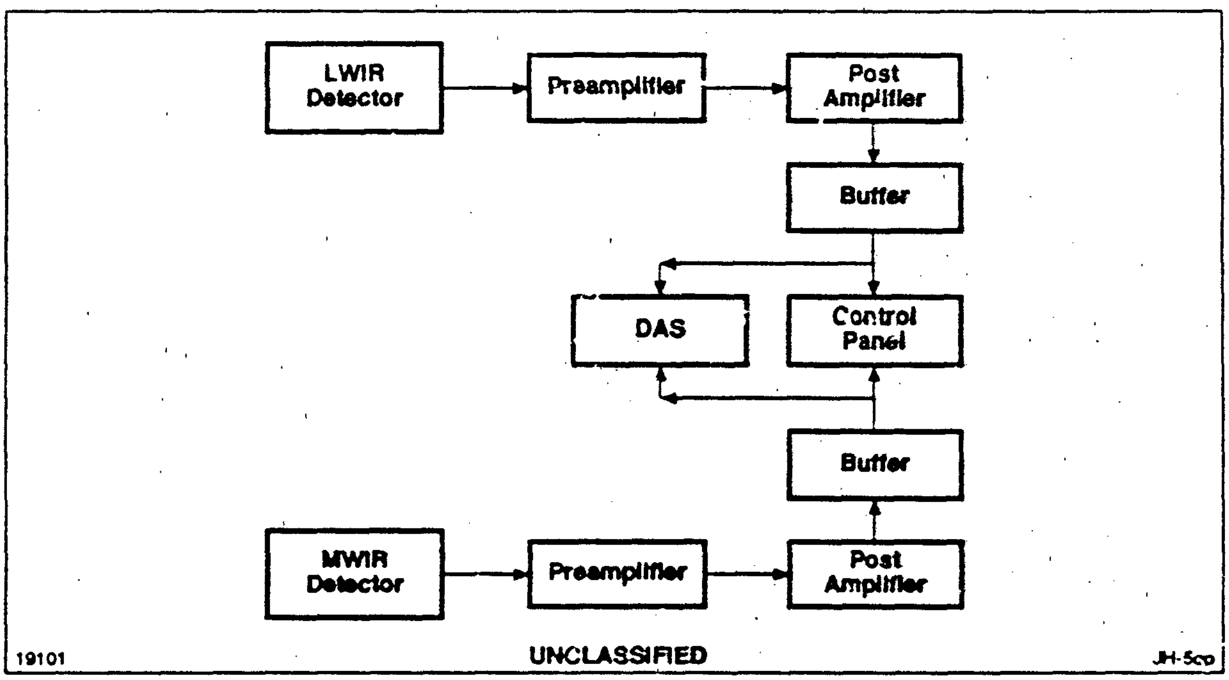

Figure 2-5 - Block Diagram of IRAAMP Sensor Signal Electronics

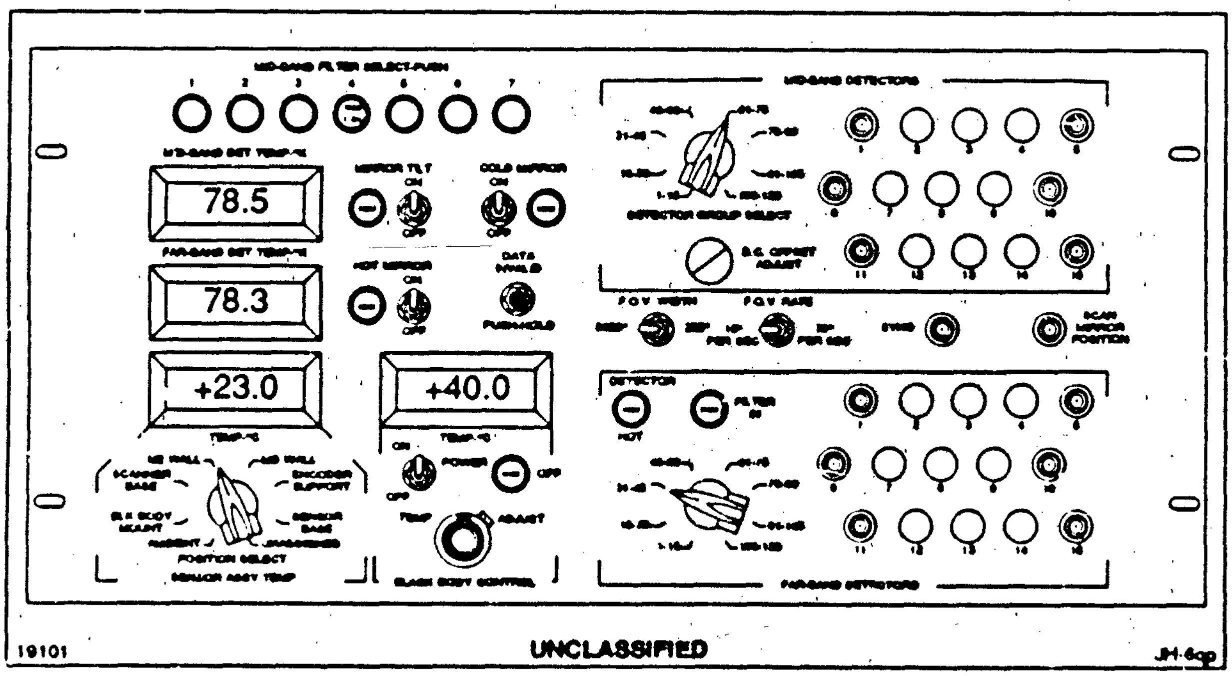

Figure 2-6 - Dual Band Sensor Control Panel

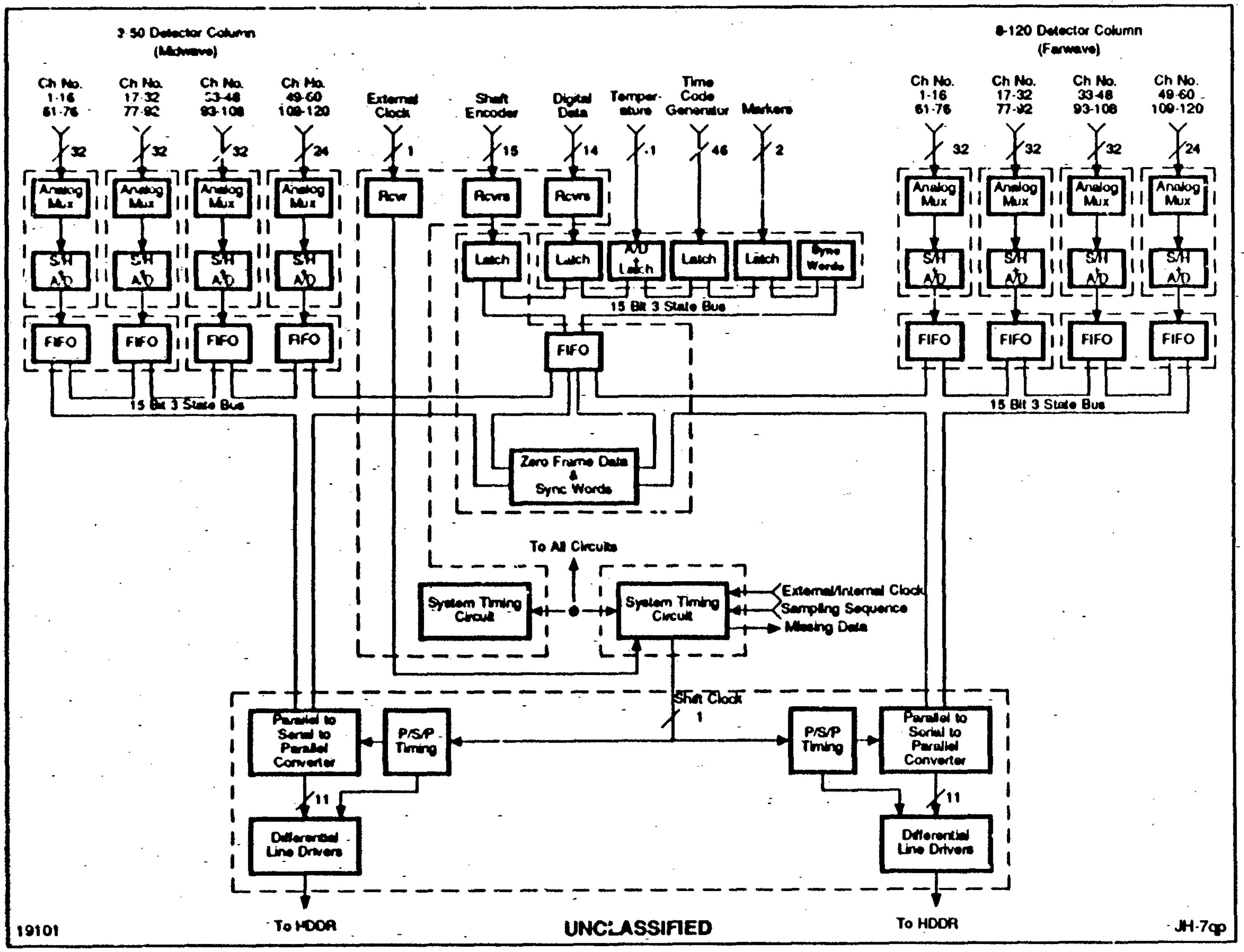

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Figure 2-7 - Digital Acquisition System

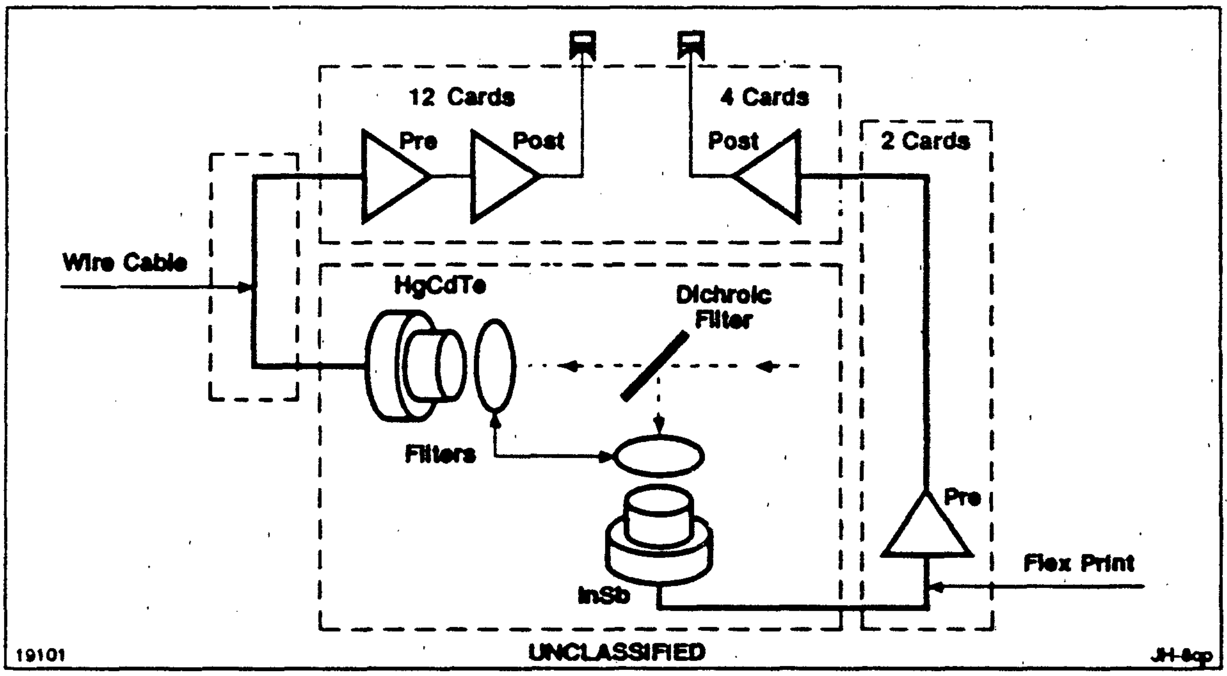

Figure 2-8 - IRAAMP Interconnection Scheme

namic input impedance, by virtue of its grounded base first stage, and very low noise characteristics. The time varying target related currents from a detector flow to the emitter of the first transistor and out of its collector. This generates a voltage of substantial level by virtue of the proportionality between the collector bias resistor and the input effective impedance. The second transistor does attenuate the amplified signal somewhat but it is configured for optimum dc biasing of the first transistor. The nominal gain of the preamplifier is 100 V/V. A bypass capacitor at the base of the first transistor renders the input dynamic impedance of this stage frequency dependent. This provides the high pass characteristics of the network. The 3 dB point of response is nominally a 0.18 Hz.

The output of the preamplifier stage is ac coupled to the postamplifier through a second order low pass filter. The ac coupling eliminates the dc offset present at the output of the preamplifier. The low pass filter band limits the system such that the pertinent target related signals are allowed to pass through, but the higher frequency noise signals are eliminated. The low pass filter is implemented to provide attenuation at 2500 Hz with 12 dB/octave roll-off in out of band frequencies, and maximally flat response within the passband.

The postamplifier consists of a low noise operational amplifier with a nominal gain of 20. The gain is adjusted during assembly for each channel in order to minimize the effect of sensitivity differences between individual detectors. The result is near equal output signal levers for a given stimulus.

The schematic for a LWIR channel is shown in Figure 2-9. The layout of the channels on a LWIR circuit card is shown in Figure 2-10. The detector channel assignments to the respective board is listed in Table 2-2. For more detail and a listing of the gain adjustment resistors, refer to drawing NSWC-84C-0060-16.

2.2.2 MWIR Pre- and Postamplifiers

The 120 MWIR postamplifier channels are located on four circuit cards in the electronics box. There are 30 channels per each circuit card. Included on each circuit card is a +12 V regulator

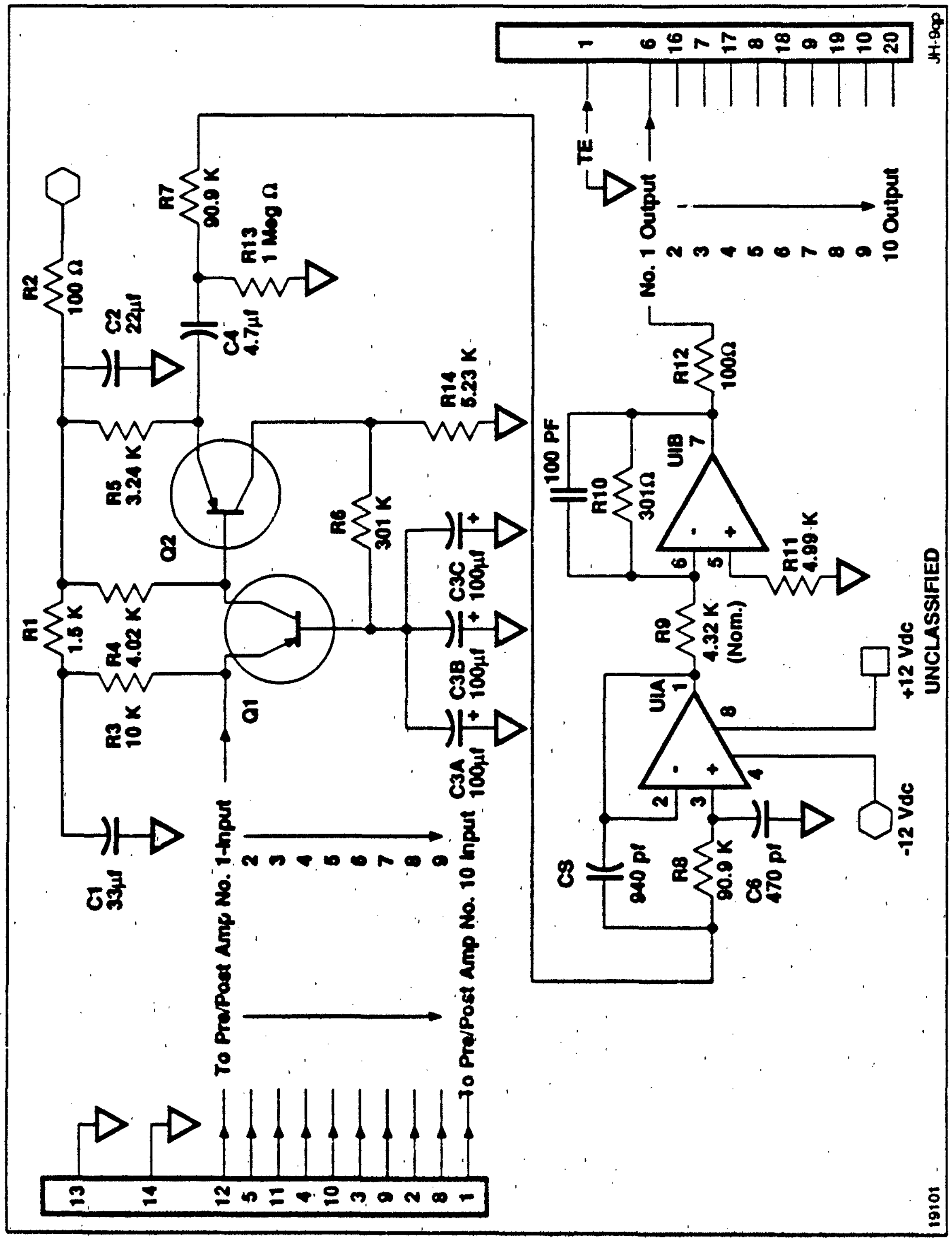

Figure 2-9 - LWIR Pre-/Postamplifier

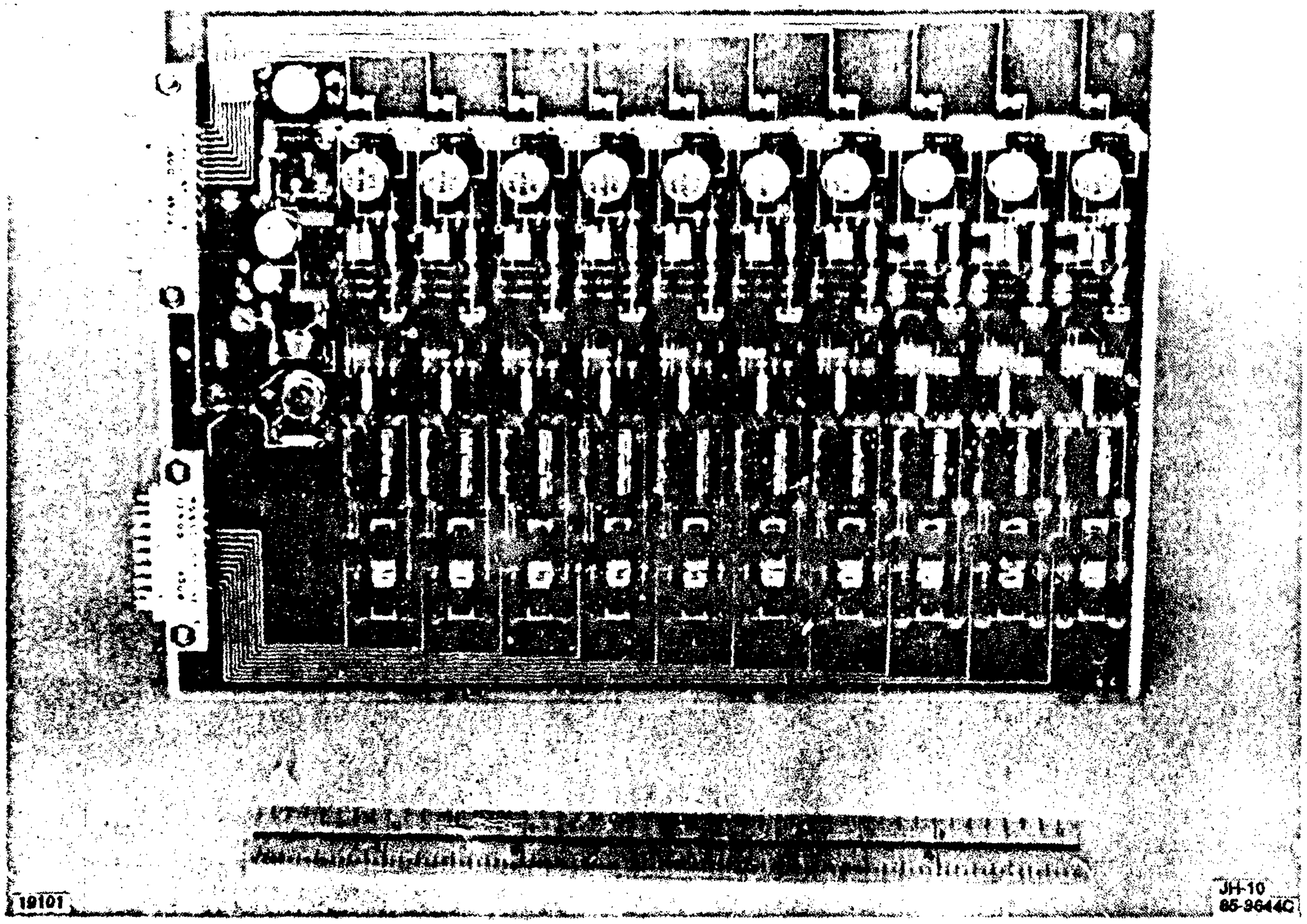

Figure 2-10 - LWIR Preamplifier/Postamplifier Circuit Card

TABLE 2-2 - LWIR DETECTOR ASSIGNMENTS

Amplifier Row No.	Pin No.	Board 1	No. 2	3	4	5	6	7	8	9	10	11	12
10	1	1	21	41	61	81	101	2	22	42	62	82	102
8	2	5	25	45	65	85	105	6	26	46	66	86	106
6	3	9	29	49	69	89	109	10	30	50	70	90	110
4	4	13	33	53	73	93	113	14	34	54	74	94	114
2	5	17	37	57	77	97	117	18	38	58	78	98	118
9	8	3	23	43	63	83	103	4	24	44	64	84	104
7	9	7	27	47	67	87	107	8	28	48	68	88	108
5	10	11	31	51	71	91	111	12	32	52	72	92	112
3	11	15	35	55	75	95	115	16	36	56	76	96	116
1	12	19	39	59	79	99	119	20	40	60	80	100	120

and a -12 V regulator which power the circuits on the card. Also, included on one of the MWIR amplifier cards is a temperature sensor circuit to sense the temperature of the MWIR detector, using a temperature sensing diode on the cold finger. This circuit sends a voltage proportional to the temperature to the front panel and to the DAS. The 120 MWIR preamplifiers, or transimpedance amplifiers, are on two flex print circuits located between the detector and the electronics box.

Transimpedance amplifiers are used to translate the current output of the high impedance InSb detectors into a usable voltage. Low noise FET input operational amplifiers are used in an inverting configuration. Because of the extremely high input impedance of the devices, the detector currents flow through the feedback resistors generating a voltage at the output and completing the current to voltage conversion cycle for signal handling.

The output of the transimpedance amplifiers are connected to the postamplifiers. The postamplifiers provides a nominal gain of three. The feedback resistor of the postamplifier is chosen such that, for a maximum given target temperature, the total signal at the output of the postamplifier is near saturation. This provides maximum dynamic range for the target temperature limits of interest. Hence, each network affords a total current to voltage conversion capability of 350e6 V/I.

As with the LWIR amplifiers, a low pass filter network is also incorporated to limit the pass band to 2500 Hz. This limits the total noise figure at the output of the amplification chain and maximizes dynamic range.

The MWIR preamplifiers, or transimpedance amplifiers, are located on the two flex print circuits which are between the detector and the electronics box. There are 60 transimpedance amplifiers on each flex-print. For the flex print circuit refer to Drawings NSWC-85C-0060-40 and -41. One end of the flex print is connected to a connector which plugs onto the detector dewar assembly. The circuit end of the flexprint contains the transimpedance amplifiers and connections for a cable, which will be connected to the backplane in the electronics box.

The schematic for a MWIR postamplifier channel is shown in Figure 2-11. The layout of each card is shown in Figure 2-12. The detector channel assignments to the respective board is listed in Table 2-3. For more detail and a listing of the gain adjustment resistors, refer to drawings NSWC-84C-0060-15.

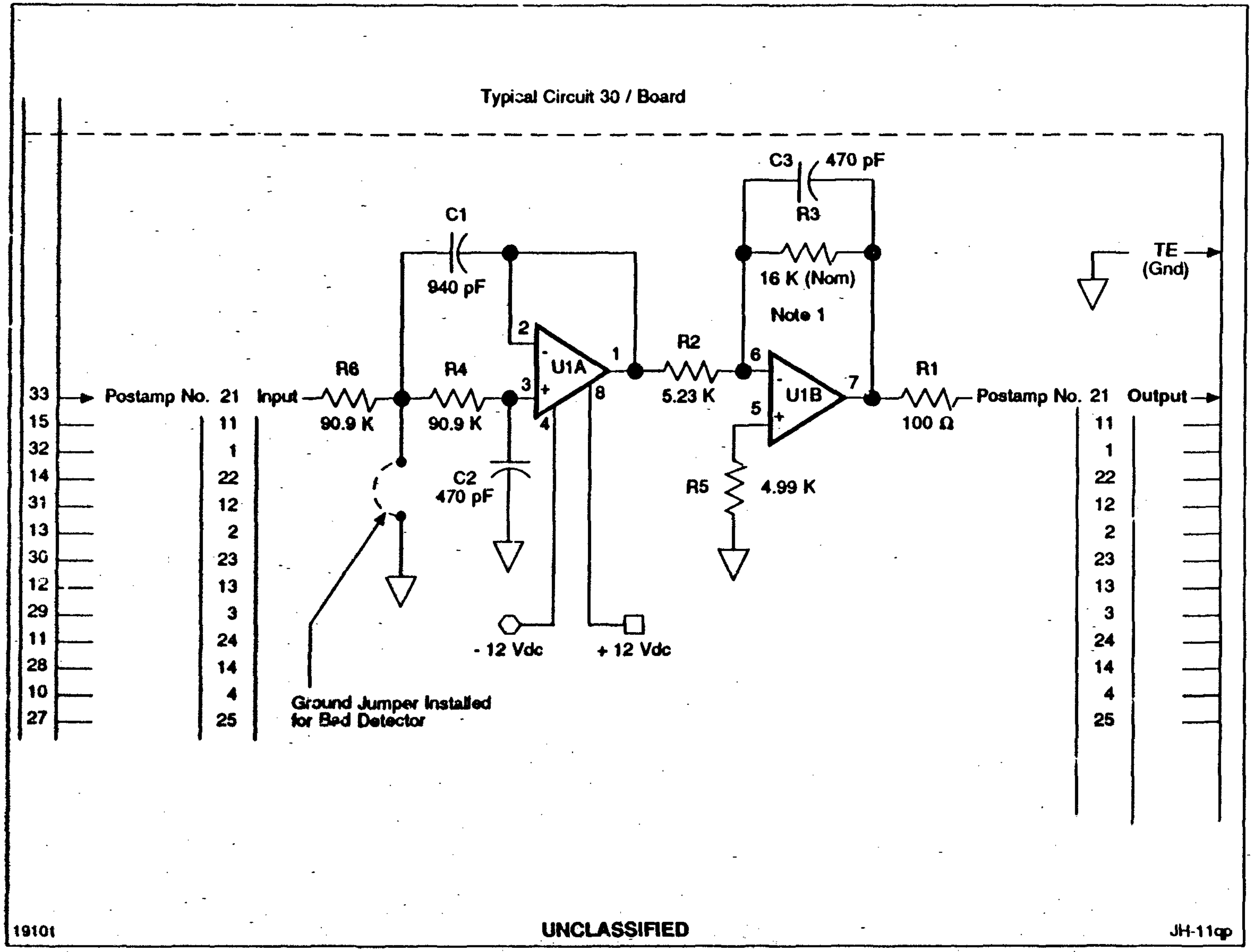

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Figure 2-11 - MWIR Postamplifier

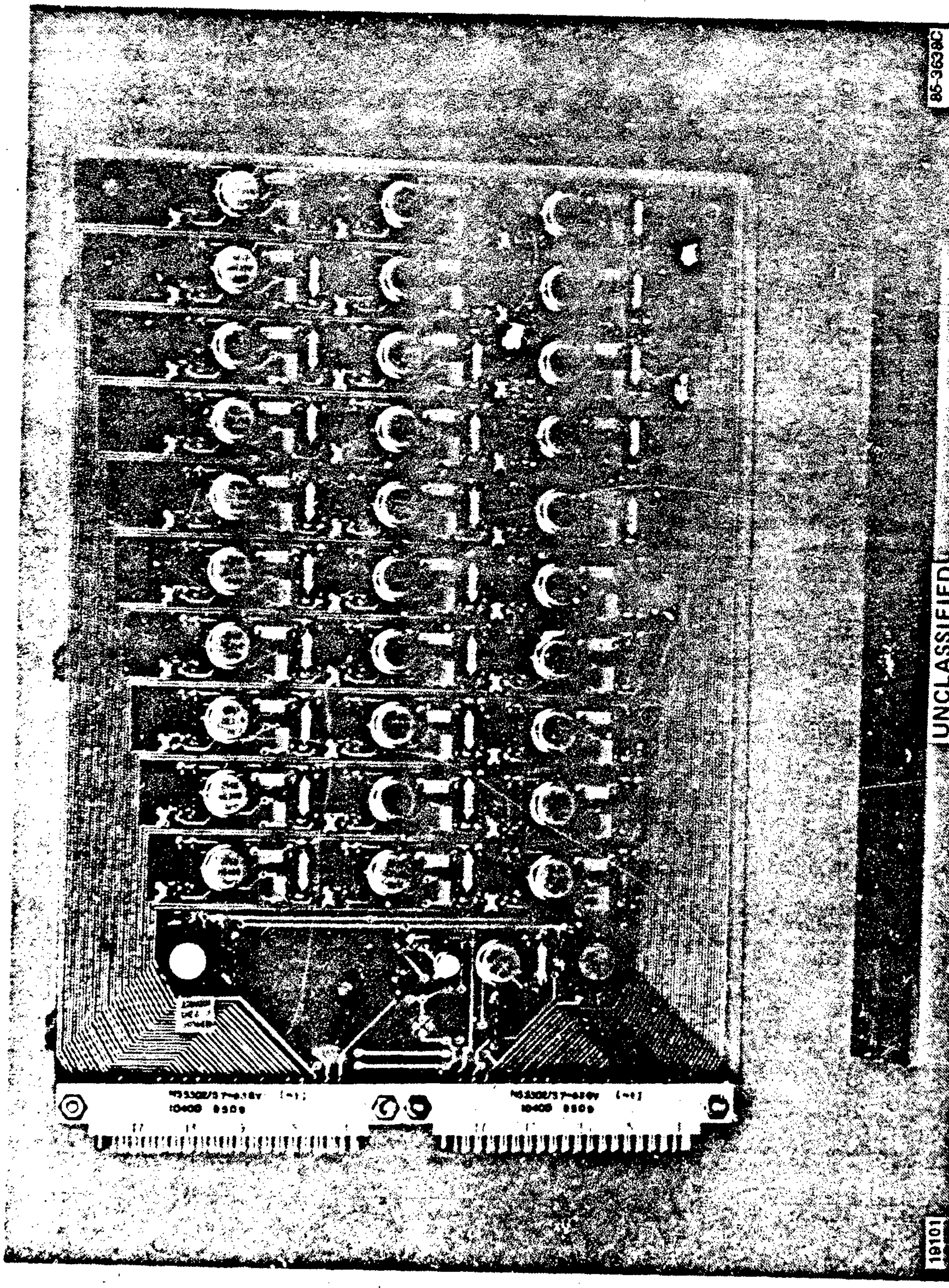
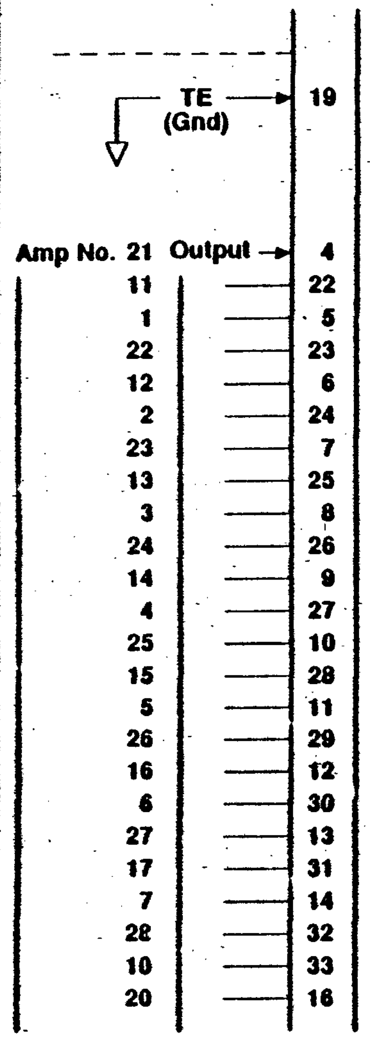


Figure 2-12 - MWIR Postamplifier Circuit Cards

TABLE 2-3 - MWIR DETECTOR ASSIGNMENTS



Detector Assignments							Grounded Amplifiers
Amplifier Number	Input J1 Pin Number	Output J2 Pin Number	Board 1	Board 2	Board 3	Board 4	
21	33	4	118	71	5	48	1
11	15	22	116	67	3	60	12
1	32	5	112	61	11	54	14
22	14	23	114	69	9	56	60
12	31	6	110	65	7	52	78
2	13	24	120	63	1	58	84
23	30	7	117	57	4	74	108
13	12	25	115	59	6	62	
3	29	8	111	47	10	64	
24	11	26	119	51	2	72	
14	28	9	101	49	8	70	
4	10	27	105	43	16	76	
25	27	10	103	55	18	68	
15	9	28	113	53	20	66	
5	26	11	109	39	12	84	
26	8	29	107	37	14	80	
16	25	12	99	41	22	82	
6	7	30	97	27	24	88	
27	24	13	89	33	34	92	
17	6	31	95	45	26	78	
7	23	14	91	29	28	94	
28	5	32	83	23	30	90	
10	22	33	79	35	44	86	
20	4	16	93	31	32	98	
30	21	34	87	17	40	104	
9	3	17	81	21	42	100	
19	20	35	77	19	46	102	
8	2	18	73	25	50	96	
29	19	36	75	15	36	106	
18	1	15	85	13	38	108	

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3. PROPOSED IRAAMP DESIGN MODIFICATIONS

It was stated in Section 1 to this Addendum that the original IRAAMP equipment was not designed with easily replaceable retrofits in mind. Therefore, it has proven necessary to redesign the original equipment with reversible changes in mind; thereby, creating a "standard" permanent modification which is retrofitable. This approach appears to be feasible with some minor shortcomings.

3.1 Proposed Modification Approach

The proposed IRAAMP modification approach will allow the IRAAMP sensor to be operated in four modes in the manner indicated in Table 1-1. Figure 3-1 illustrates the configuration of each of the four modes. Here it is noted that the various modification options involve both opto-mechanical and electro-mechanical changes when compared to the original configuration illustrated in Figure 2-8.

The opto-mechanical changes involve:

- The beam splitter
- Optical filters
- LWIR/MWIR optical detectors together with their supporting faceplates

The electro-mechanical changes involve:

- Electronics box backplate wiring
- LWIR detector to pre-/postamplifier backplate electronics wiring
- LWIR detector pre-/postamplifier circuit cards
- MWIR detector flexprint preamplifier wiring
- MWIR preamplifier to postamplifier backplate postamplifier circuit cards.
- MWIR postamplifier circuit cards

The proposed system will be modularized into the base system, plus optical components, electronic components and mechanical components. The optics include the dichroic beam splitter or a wire grid polarizer and the subband spectral filters. The electronics include the amplifier circuit cards. The mechanical components include the MWIR and LWIR detector faceplate assemblies. The MWIR faceplate assembly includes the enclosure for the MWIR transimpedance amplifier flexprint circuits. The LWIR detector faceplate assembly includes the enclosure for the connection harness between the detector and the electronics box.

3.2 Proposed Optical Modifications

The opto-mechanical modifications required to allow the current IRAAMP sensor to satisfy the new configurations are minor in principle. Refractive beam splitter and filter elements are constructed of the same materials and material thicknesses, thereby, maintaining the same optical paths for the same wavelengths. When one of the two detected optical channels change from MWIR to LWIR or vice-versa, then a minor refocusing of the changed channel is adequate to restore the desired optical characteristics.

3.2.1 Modification Option 0

Figure 3-2 shows a schematic optical diagram of the current IRAAMP sensor and Figure 3-3 shows the requirements for the dichroic beamsplitter. Table 3-1 gives the optical prescription. Specified beam splitter coating efficiencies and >80 percent in transmission for 7.4-13.0μm and >80 percent reflectance for 2.0-5.4μm. The beamsplitter substrate is polycrystalline germanium, 1.5 in. x 1.5 in.^{2} and 0.100 in. thick. The MWIR arm has a filter wheel with positions for six bandpass filters of which five are currently used. The LWIR arm has option to select between two bandpass filter. The measured system performance is better than the 0.25 mrad specification, therefore it is desirable to

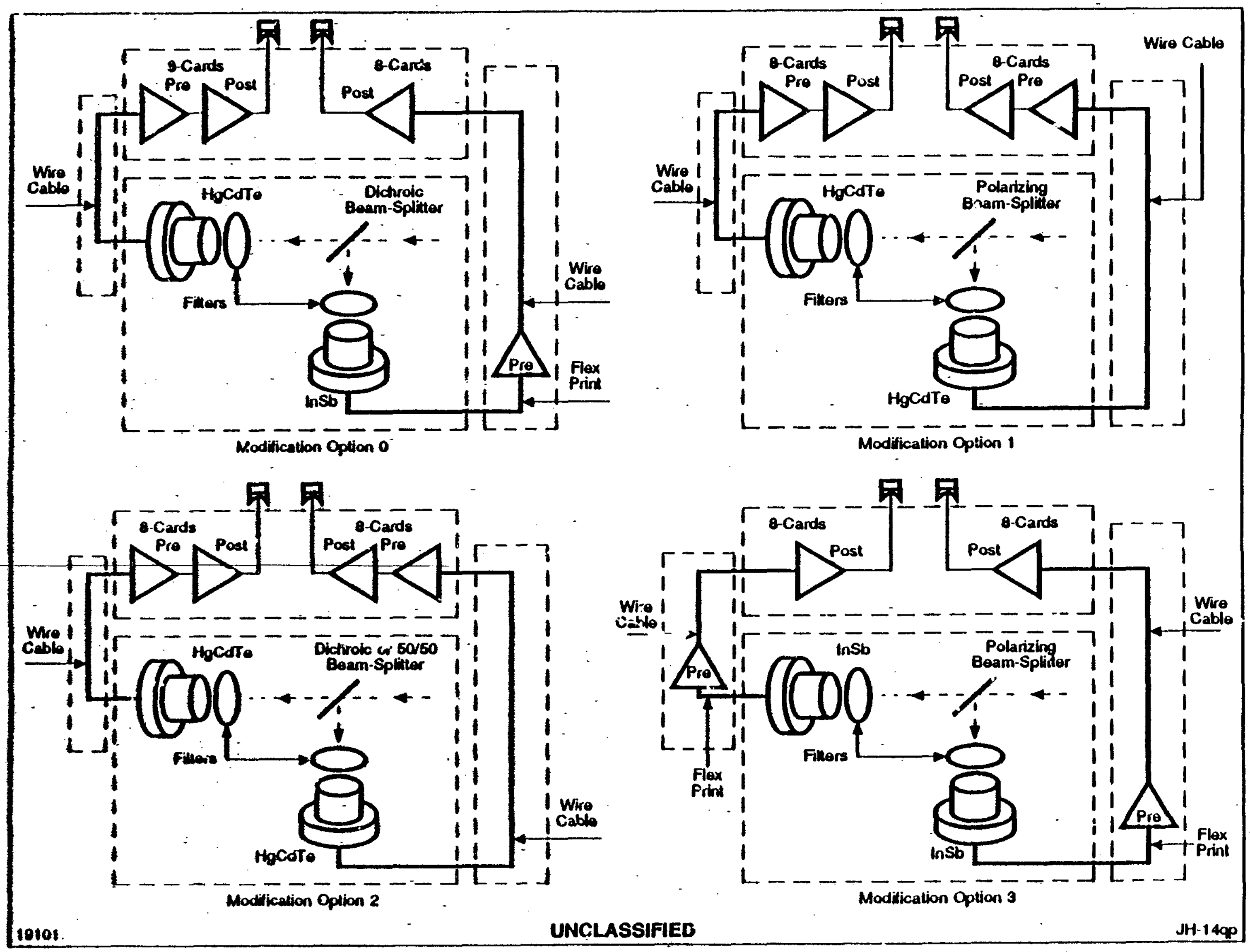

Figure 3-1 - Configurations of Proposed Modification Options use the same substrate material and thickness (where appropriate) to minimize performance changes to the existing system. Proposed alterations to the baseline sensor detailed below will involve disassembly, reassembling and realignment of the beamsplitter assembly, but will not impact optical performance of the system. The only foreseen changes may be in overall system sensitivity, since the proposed alternate beamsplitters may have efficiencies different from the unit now in use.

3.2.2 Modification Option 1

As uncoasted Ge wire grid polarizer will reflect radiation polarized perpendicular to the plane of incidence and transmit polarized radiation parallel to the plane of incidence. Polarization ratios are 80 percent for the reflected energy and 100% for the transmitted energy. The specifications for the uncoated Ge polarizer should have a 1.20 - 1.25 in. diameter and 0.08 - 0.10 in. thickness, ARIES of Concord, MA has in stock a No. 12.700, uncoated Ge polarizer. This polarizer consists of an array of parallel aluminum conductors supported on a Ge substrate. The aluminum is deposited using a photolithigraphic technique. The wire grid line spacing are 0.4 μm with an extinction ratio of 180 at 10 μm. Two bandpass filters at the specified LWIR wavelengths are also required in front of the two detectors. The wire grid polarizer used at 45 deg will cause the system sensitivity to be lower than modification option zero since the beam splitter is roughly 50/50 intensity wise.

Since this modification uses a LWIR detector in the Modification 0 MWIR channel, a second LWIR detector and a MWIR-type supporting face plate must be provided. This channel must also be equipped with appropriate optical filters.

3.2.3 Modification Option 2

Except for a change in the beamsplitter and the separate channel filters, this Modification Option 2 is similar to 1 above.

A 50/50 Ge substrate beamsplitter having 1.20 - 1.25 in. diameter and 0.08 - 0.10 in. thickness is specified along with two LWIR bandpass filters at the desired wavelengths placed in front of the two detectors.

An alternate approach can be used if the desired wavelengths are separated by a marginal distance; then, a longwave dichroic beamsplitter could be used. This beamsplitter could increase the efficiency and therefore increase the system sensitivity to greater than 50 percent efficiency for each waveband channel.

3.2.4 Modification Option 3

An uncoated Ge wire grid polarizer set at 45 deg. with the polarizer grid lines perpendicular to the plane of incidence to give 80 percent of the reflected beam polarized and 100 percent of the transmitted beam polarized. The uncoated Ge polarizer should be 1.20 - 1.25 in. diameter and 0.08 - 0.10 in. thick with a grid line spacing of 0.4 μm. Two bandpass filters at the specified MWIR wavelengths are required in front of the two detectors. Note: The wire grid polarizer used at 45 deg. will cause the system sensitivity to be lower, due to the fact that a 50/50 beamsplitter is needed to use the polarized beams in both channels.

Reference to Figure 3-1, shows that since this modification uses a MWIR detector in the Modification 0 LWIR channel, a second MWIR detector and a LWIR-type supporting faceplate must be provided. This new MWIR channel does not have room for the many position MWIR filter wheel. Therefore the LWIR type two-position filter holder must be equipped with appropriate MWIR filters.

3.3 Proposed Electrical Modifications

The electromechanical modifications required to allow the current IRAAMP sensor to satisfy the new configuration are considerable prior to the output of the post amplifiers in the electronics

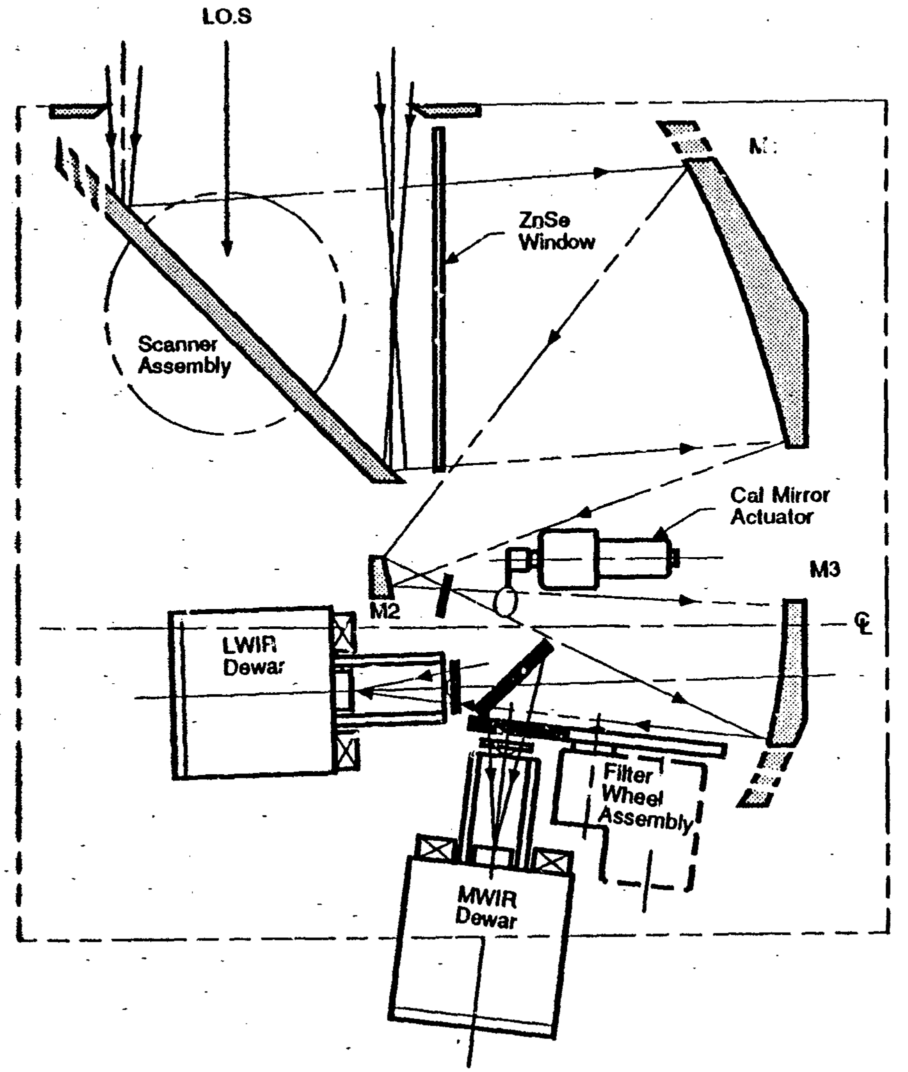

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Figure 3-2 - IRAAMP Optical Schematic

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11-20-84	J.N.M.

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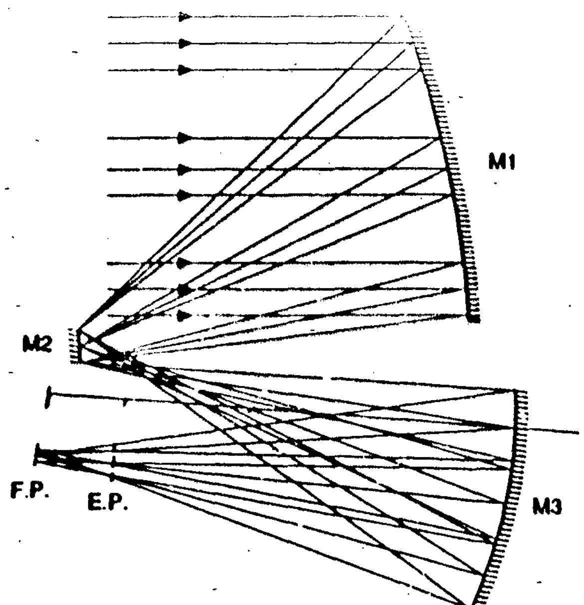

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box shown in Figure 2-1. The remaining electromechanical parts of the IRAAMP system (i.e., the interface electronics, control panel, DAS, power supplies, etc.) remain essentially unchanged. This problem arose due to the fact that the LWIR and MWIR signal channels did not originally have mechanically symmetric circuit board wiring.

3.3.1 Modification Option 0

3.3.1.1 Electronics Configuration

The present electronics box contains 16 cards; 12 cards, each containing 10 pre- and postamplifiers for the LWIR detectors; and 4 cards, each containing 30 postamplifiers for the MWIR detectors. In the proposed configuration the electronics box will still contain 16 cards, but will use eight cards for each detector instead of 12 for the LWIR detector and four for the MWIR detector. (See Figure 3-4). Each circuit card will contain 15 amplifier channels: either 15 LWIR pre- and postamplifier channels, or 15 MWIR postamplifier channels. The present electronics box structure will still be used, with only a wiring change needed. This configuration will require that the backplane wiring of the electronics box be changed to meet the new configuration of eight card per detector instead of 12 for the LWIR and four for the MWIR. With the selected detectors installed, and connected to the electronics box, the appropriate eight cards for that detector type, LWIR or MWIR, are inserted into the electronics box. This allows for detector types to be easily changed without any additional wiring changes.

Figure 3-5 shows the present component layout of a LWIR pre/postamplifier board. Figure 3-6 shows the proposed layout, with each block containing two channels. Note that there are eight blocks on the board, which would give 16 channels; only 15 channels are required. This extra channel may be included as a spare channel, or as a test channel, or totally eliminated. The layout is done using surface mount resistors and capacitors; note that the layout shows area for device including the mounting and required connection area. The operational amplifiers are in a quad package, instead of the dual presently used, and the transistors are still discretes. The base circuit designs for the amplifiers do not need to be changed. The present MWIR boards contain 30 postamplifier channels. The proposed board will contain only 15 channels, the present components can still be used, see Figure 3-7. The change to the electronics will entail making 16 new LWIR pre/post amplifier cards and 16 new MWIR postamplifier cards; this will satisfy conditions when two LWIR detectors or two MWIR detectors are used.

On one of the eight circuit cards of the LWIR pre-/postamplifier assembly and on one of the eight circuit cards for the MWIR postamplifier assembly, a temperature monitoring circuit will need to be included, to monitor the temperature of the two detectors. The layout of all the cards should include the temperature monitoring circuit, though it needs only be installed on two of the 16 LWIR cards and on two of the 16 MWIR cards (for the cases where two identical detectors are used). For ease of use it is recommended that the circuit be installed on all of the cards (16 LWIR and 16 MWIR), so that during an installation of a new detector type, the operator will only have to install the appropriate eight identical cards for that detector. Making the circuit cards identical, for each detector type, will also keep the cost of designing and building the boards to a minimum. A schematic of the temperature monitoring circuit is shown in Figure 3-8.

Also, at least two new flexprints containing the MWIR transimpedance amplifiers will need to be fabricated for the case of two MWIR detectors being used. The present design uses two flexprint designs each containing 60 transimpedance amplifiers. The layout for one of the present flexprint circuits is shown in Figure 3-9. The other flexprint circuit differs only in the structure of the detector connection end. The present flexprint design for the MWIR transimpedance amplifiers may be used, though it would be advisable to redesign these. In the Conclusions and Recommendations of the Dual Band Final Report, BR-17965, it stated that the reliability of the MWIR array could be improved by replacing the current flexprint interconnect. A small multilayer board could be made

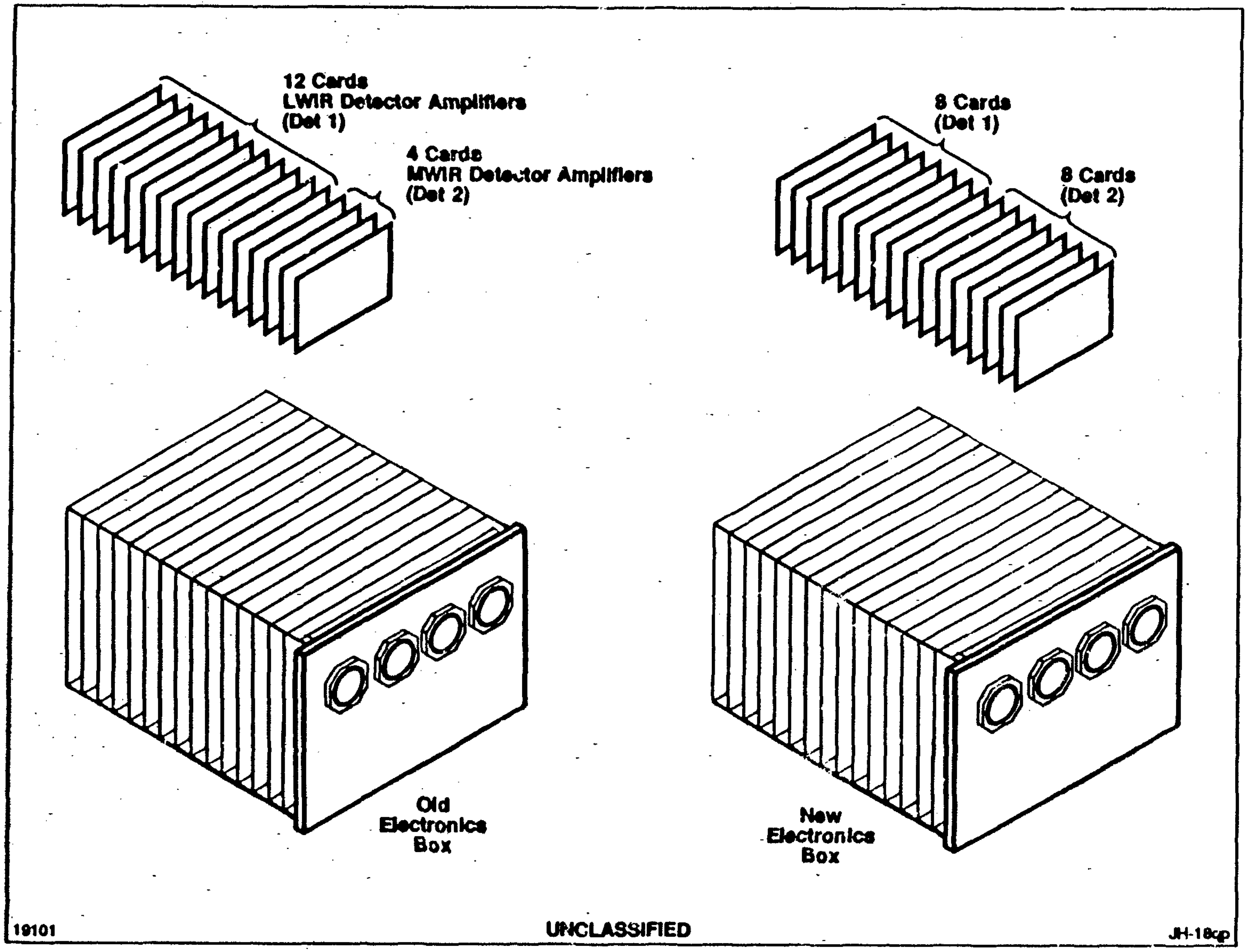

Figure 3-4 - Electronics Box Configuration (8 Cards Per Detector Instead of 12 LWIR and 4 MWIR Cards)

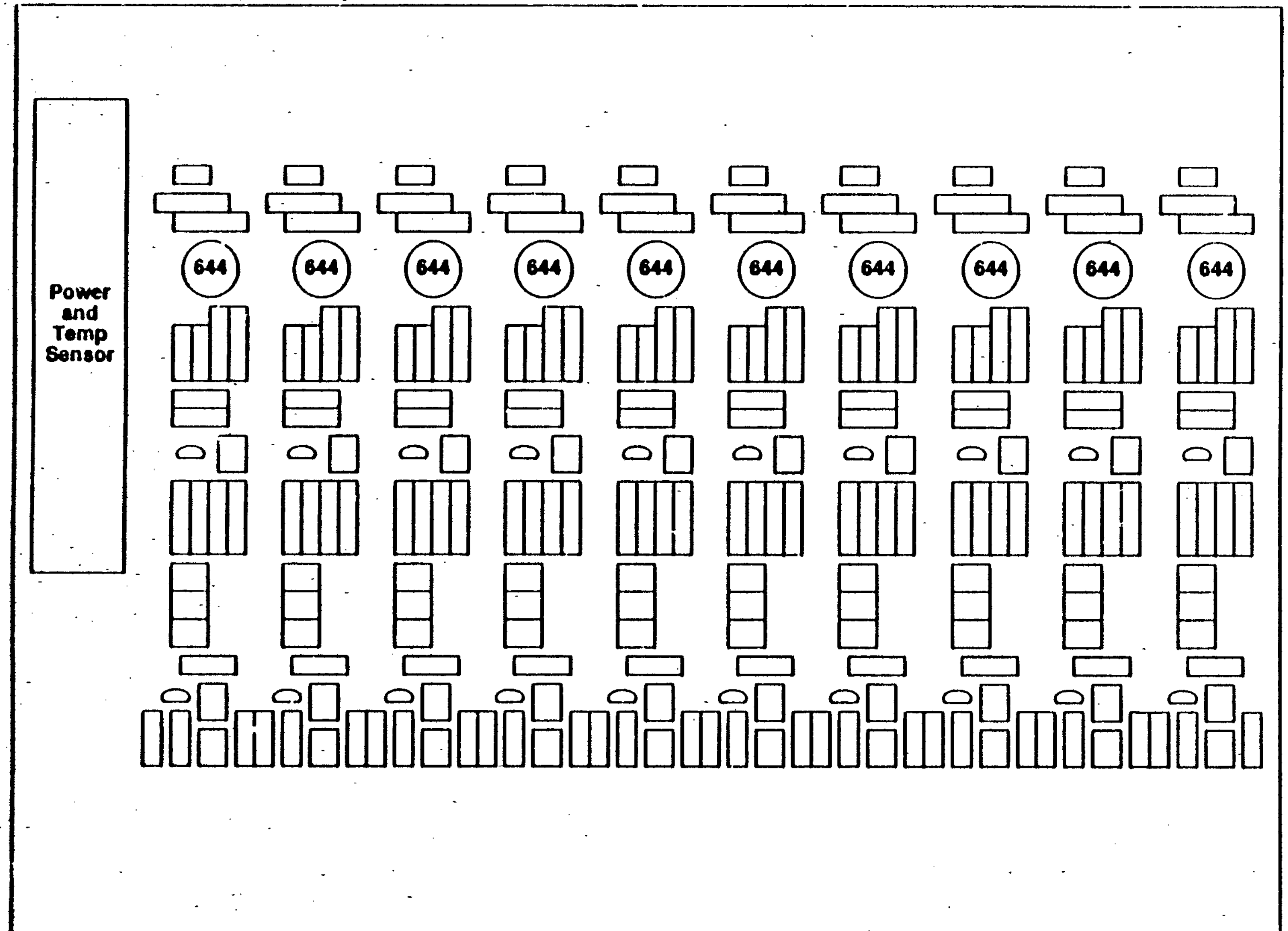

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Figure 3-5 - Present Layout of LWIR Pre-/Postamplifier Board

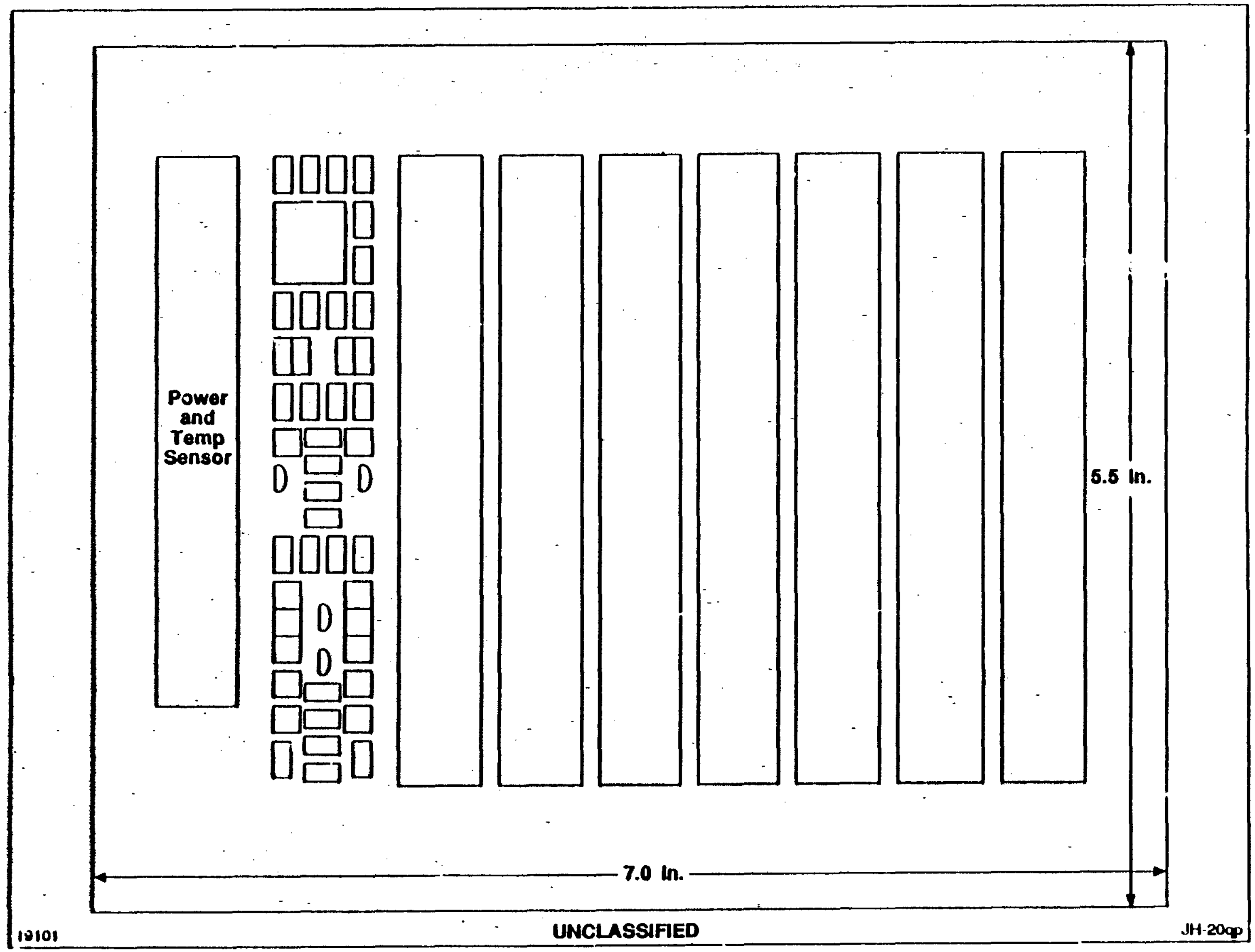

Figure 3-6 - Proposed Layout of LWIR Pre-/Postamplifier Board

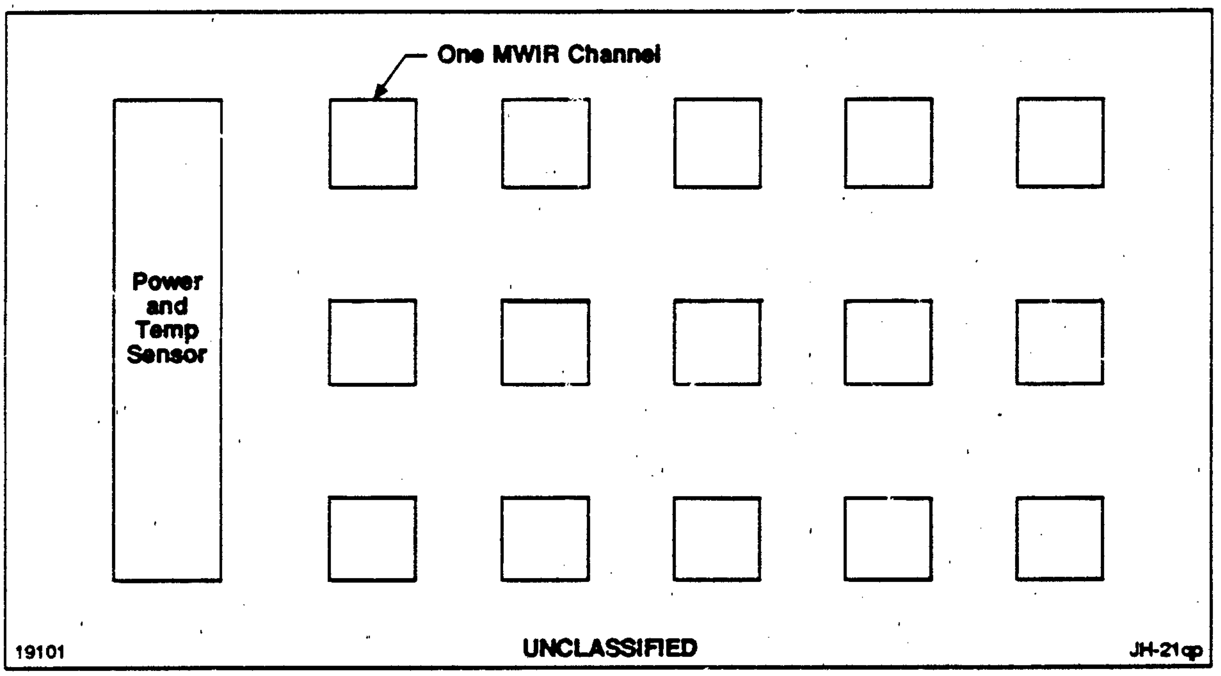

Figure 3-7 - Proposed Layout of MWIR Postamplifier Board

to contain all 120 transimpedance amplifiers, using quad op amps instead of the duals presently used. The connections could be made using ribbon cable instead of the flexprint, which will increase reliability.

3.3.1.2 Electro-/Opto-Mechanical Configuration

The detector faceplate assembly will contain the detector mounted to the faceplate and will enclose the interface wiring to the amplifiers in the electronics box. For the MWIR detectors this interface wiring contains the preamplifier assembly on the two flex print circuits. The mounting structure for the LWIR and the MWIR detectors are different. This difference includes the detector mounting surface, and the space and covers which enclose the connections between the detector and the preamplifiers. For modularity, the physical structure of the face plate assemblies should allow for using either a LWIR detector or a MWIR detector in either location.

The modular system will include four faceplate assemblies. This is two styles of faceplates, one to be used in place of the present LWIR detector faceplates and the other to be used in place of the present MWIR faceplate. There will be two faceplates of each type made, so that the MWIR transimpedance amplifier circuits, or the LWIR connection harness is installed once in the faceplate. This will give two pairs of faceplates. When a new detector type is installed, the appropriate faceplate is selected and the detector is mounted to the faceplate and the assembly is mounted to the sensor assembly.

Each faceplate in a pair is identical except that the one to be used for a MWIR detector will contain the transimpedance amplifier flex print assembly instead of the direct wiring harness that is used for the LWIR detector.

The faceplate used for the present LWIR detector will need to be modified to allow for installation of the MWIR transimpedance amplifiers; when the system is configured with two MWIR detectors. When a LWIR detector is used the transimpedance amplifier assembly is replaced with a direct wiring harness to connect the LWIR detector to the backplane of the electronics box. See Figure 3-10.

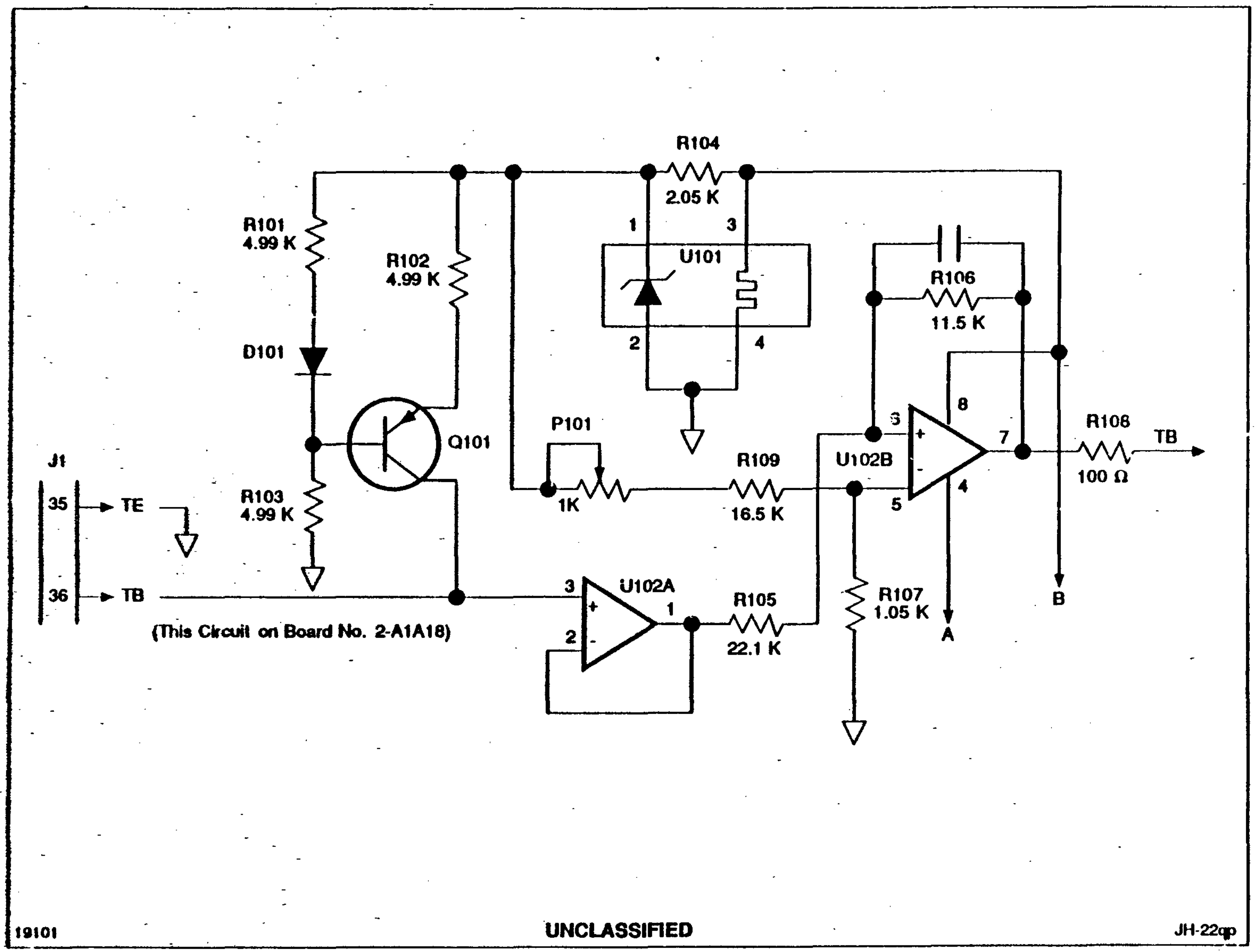

Figure 3-8 - Temp Sensing Circuit

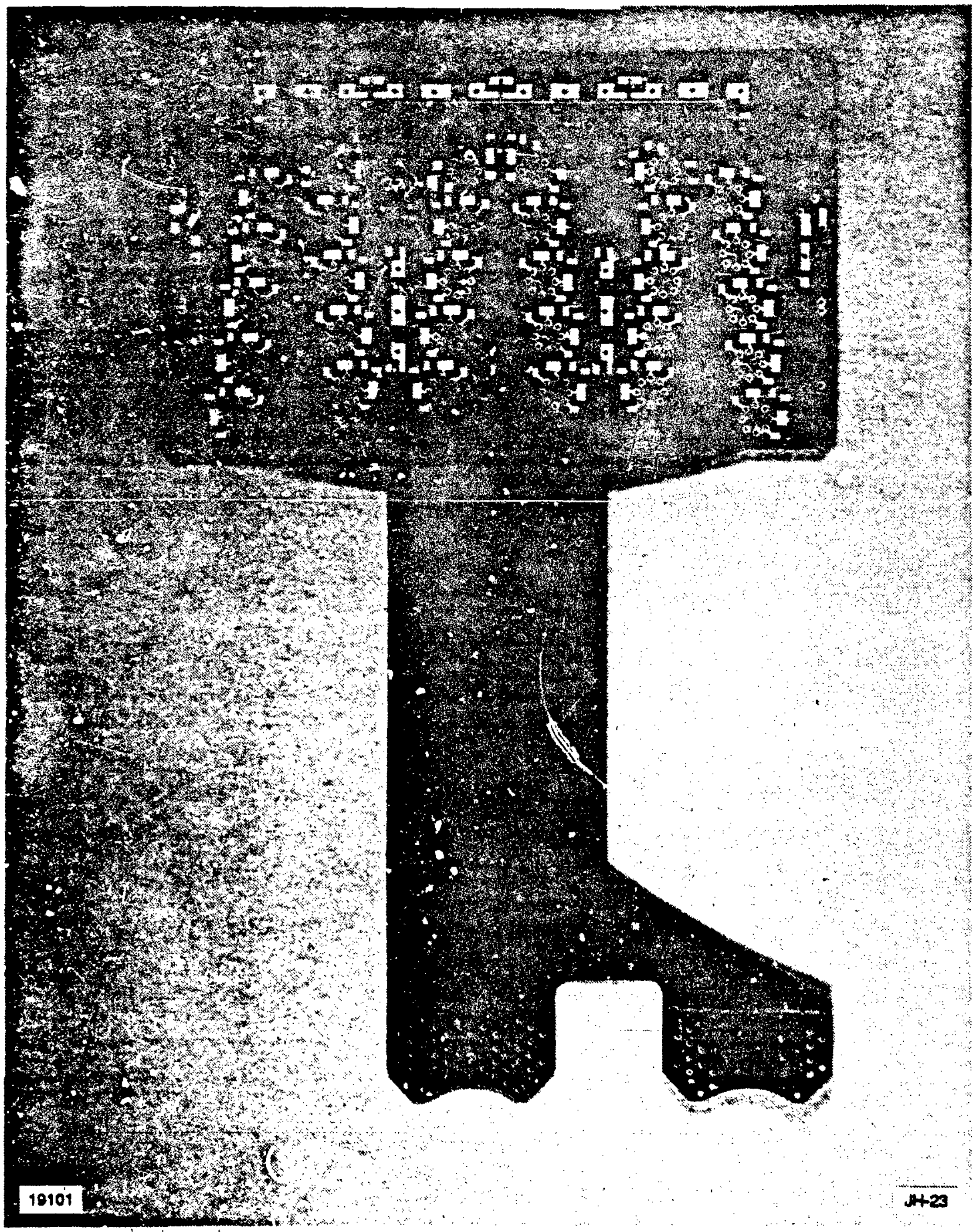

Figure 3-9 - MWIR Transimpedance Amplifier Flexprint Circuit (1 of 2)

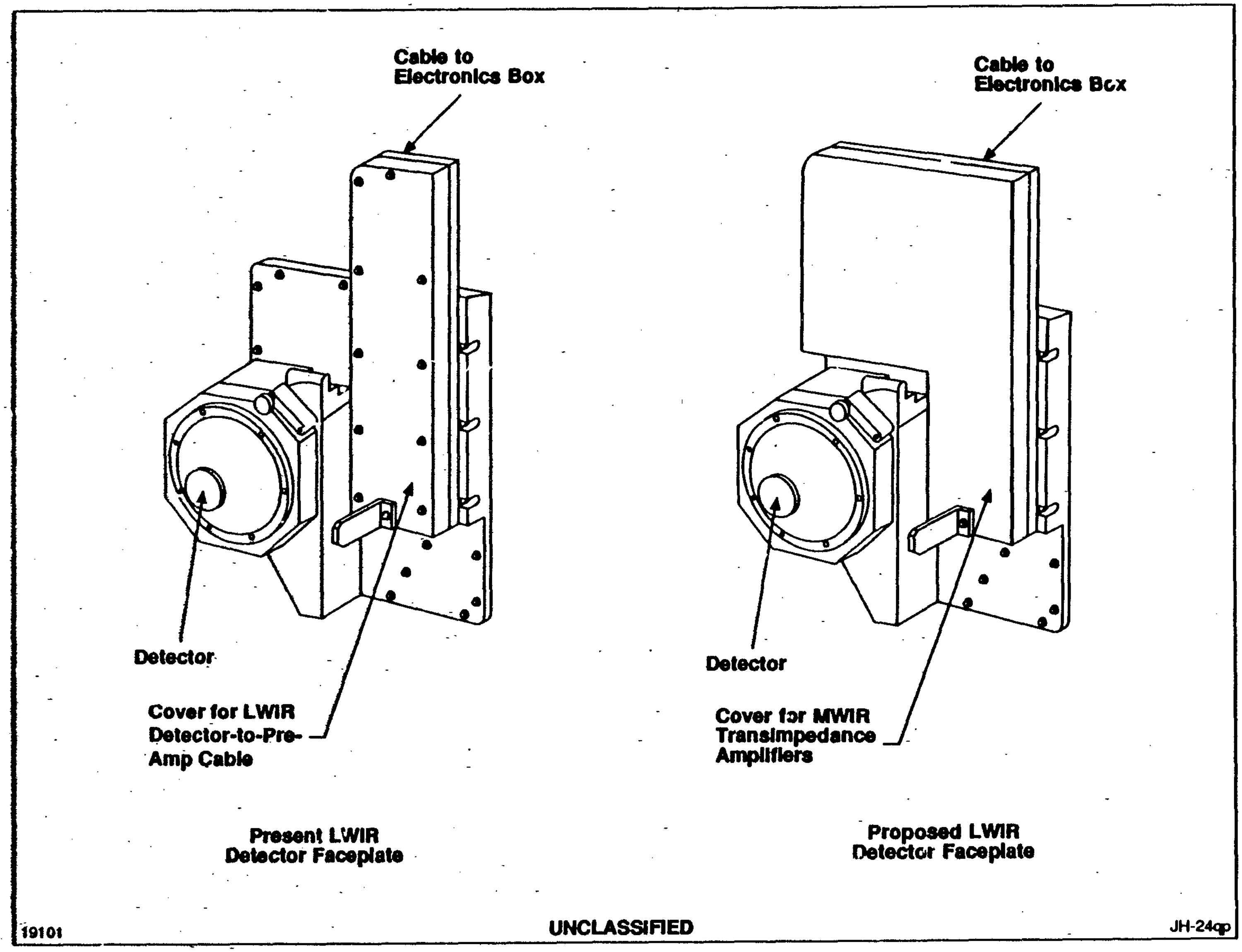

Figure 3-10 - Modification to Present LWIR Detector Faceplate Which Allows Use of MWIR Detector

The MWIR faceplate assembly can be identical to that presently used, and the only alteration needed for a LWIR detector to be used is for the MWIR transimpedance amplifiers to be replaced with a direct wiring harness.

3.3.2 Modification Options 1, 2 and 3

The proposed upgrade to the present IRAAMP sensor will allow the system to be configured with two 120 channel LWIR detectors, or with two 120 channel MWIR detectors, while still retaining the present capability of using a 120 channel LWIR detector and a 120 channel MWIR detector. This upgrade will be modular so as to make the sensor configuration changes as simple as possible.

When a new detector type is to be installed in the IRAAMP sensor, the old detector and faceplate is removed. The eight circuit cards for that detector are removed. The beamsplitter is changed as necessary: install either the dichroic or the appropriate wire grid polarizer. Change the subband spectral filters as necessary. Install the new detector with its appropriate faceplate assembly (which includes either the MWIR transimpedance amplifiers or the LWIR connection harness). Insert the appropriate eight circuit cards for the respective amplifier. Connect the cryostat assembly to the new detector, and replace all covers. The system is now ready for operation.

4. SUMMARY AND CONCLUSIONS

This Addendum to the Air-/Ground Based IR Background Measurements Program Final Report contains a summary discussion of possible IRAAMP sensor modifications which will permit expanded capabilities for the system. In particular, a "standard" permanent modification, with outputs identical to the original IRAAMP sensor, is recommended which allows three new system configurations to be implementable in a conveniently reversible fashion. These three new optional configurations allow measurements to be taken as follows:

Option 1: Allows IRAAMP sensor infrared radiation measurements in the LWIR band in two cross-polarized channels, simultaneously.

Option 2: Allows IRAAMP sensor infrared radiation measurements in the LWIR band in two subband spectral channels, simultaneously.

Option 3: Allows IRAAMP sensor infrared radiation measurements in the MWIR band in two cross-polarized channels, simultaneously.